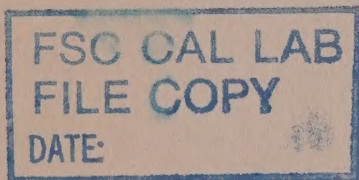


INSTRUCTION MANUAL



E-I-R METER

MODEL 110A

SERIAL # 337

C.R.T. TEST EQUIPMENT DESIGD

12/5/60 Red.

[TEK ITEM - 10302]



HEXEM, INC.

Precision Electronic Instruments

P.O. Box 636

LOS GATOS, CALIFORNIA

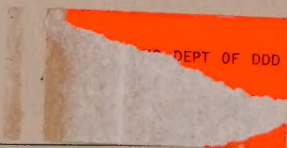
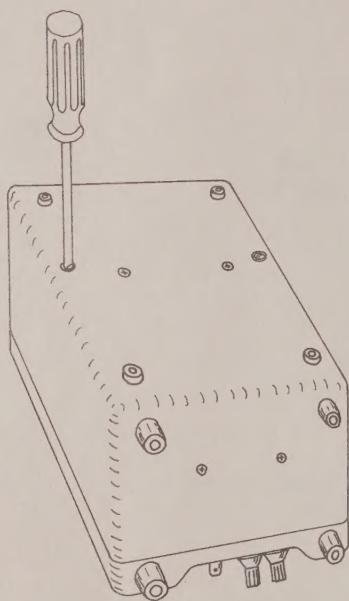


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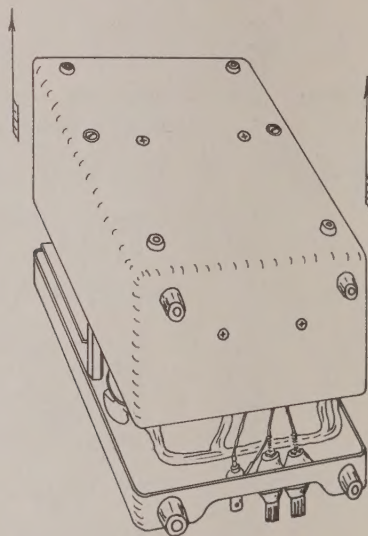
Model 110A

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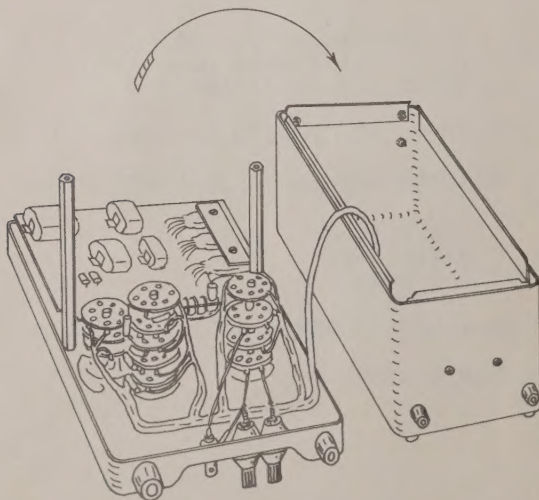
FIG. 1. OPENING THE INSTRUMENT FOR INSPECTION AND MAINTENANCE



- A. PLACE INSTRUMENT FACE DOWN ON RESILIENT SURFACE (FELT, SHOP CLOTH, PAPER PAD, ETC.) RELEASE TWO SLOTTED HEAD CAPTIVE SCREWS



- B. RAISE BACK COVER VERTICALLY UPWARD UNTIL BATTERY PACK CLEARS SWITCHES



- C. THEN ROTATE BACK COVER OVER ONTO ITS FEET SO THAT IT LIES ALONGSIDE MAIN PORTION OF INSTRUMENT

MODEL 110A E-I-R METER

1. GENERAL DESCRIPTION

1.1 The Model 110A E-I-R Meter is a battery-powered instrument for the direct current measurement of voltage, current and resistance. Approximately 1000 hours of continuous operation are available before batteries must be replaced; in intermittent operation, somewhat longer life will be realized.

Battery operation of the instrument provides for expanded usefulness, rapid stabilization following turn-on and the capability of operation in making measurements on sensitive circuits where AC lines operated instruments are liable to introduce disturbing unwanted signals. In addition, self-contained battery power permits operation many kilovolts off ground if necessary.

The large center-zero meter provides direct indication of polarity and a 1-3-10 series of scale values on voltage and current indications prevents undue deterioration of accuracy due to poor scale overlap.

Typical uses for the Model 110A E-I-R Meter includes the measurement of leakage currents and resistances, grid currents of vacuum tubes, semiconductor characteristics and potential measurements in high resistance circuits such as computer circuits. It may be used as a null indicator, as a deviation bridge limit indicator and for reading direct, deviations from a reference voltage. Some applications of this meter are discussed more fully in a separate section of this Instruction Manual.

1.2 Specifications

Voltage Ranges: $\pm 1, 3, 10, 30, 100, 300$ millivolts full scale; $\pm 1, 3, 10, 30, 100, 300, 1000$ volts full scale. Accuracy, exclusive of zero drift, $\pm 2\%$ or better. Input resistance 101 megohms.

Current Ranges: $\pm 1, 3, 10, 30, 100, 300$ milliamperes full scale; $\pm 1, 3, 10, 30, 100, 300$ microamp-

eres full scale; +1, 3, 10, 30, 100, 300 milliamperes full scale. Accuracy, exclusive of zero drift, +2% or better. Voltage drop 100 millivolts.

Resistance Ranges: 10, 100 ohms center scale; 1, 10 and 100 kilohms center scale; 1, 10 and 100 megohms center scale. Accuracy at midscale +4% or better. Accuracy at 0.3 and 3.0 on scale +5% or better. Internal check voltage 1.5 v.

Drift: Drift after five-minute stabilization period is less than 3 millivolts for the first hour and less than 1 millivolt per hour thereafter with relatively constant ambient temperature.

Temperature Effects: Operates within accuracy limits specified from -30°C to +50°C. The low temperature (below -20°C) characteristics of the "D" cell used for a resistance measurement voltage source prohibit low temperature measurement of resistance on the 10 ohm center scale.

Probe for Voltage Measurements: Contains 1 megohm isolation resistor; nominal shunt capacitance is 4 μ farads.

Battery Life: Approximately 1000 hours before replacement of shortest lived batteries in complement. Heavy usage of meter in resistance measurement on lowest resistance scale may lead to prior replacement of "D" cell.

Dimensions: 6-1/2 inches wide by 9-5/8 inches high by 5-3/8 inches deep, overall.

Weight: Seven pounds with batteries.

1.3 CONTROLS: Five panel controls perform the following functions:

1.3.1 ZERO: Adjust for zeroing meter. (vernier control)

1.3.2 RES-ADJ: Adjust for full scale reading in resistance measurement prior to measuring unknown.

1.3.3 ON-OFF & BATT-TEST Switch: Performs ON-OFF switching and checks 3 A & B batteries, useful range indicating on meter. Voltage is applied to all filaments when switch

is rotated to BATT-TEST A₁ position and remains on through BATT-TEST B position into ON position. In this manner application of filament voltage precedes application of plate voltage.

1.3.4 E-I-R SELECTOR SWITCH: Selects voltage, current or resistance measurement with initial control of indicated full scale value.

1.3.5 RANGE SELECTOR SWITCH: Selects full scale value of current and/or voltage scale and multiplier for resistance scale.

1.3.6 COARSE ZERO: Coarse control, screw driver adjustment.

2 OPERATING INSTRUCTIONS

2.1 Meter Mechanical Zero: Before turning the instrument ON check the mechanical zero of the instrument. The mechanical zero of the Model 110A E-I-R Meter is at the center of the upper scale. If necessary reset with the meter zero adjustment--black slotted head adjustor on front of meter case.

2.2 Turn-On Procedure: In order to reach the ON position the ON-OFF switch must be turned through the BATT-TEST positions. In each of these positions note whether or not the needle indicates that these batteries are still in the USEFUL BATT. RANGE. For the VOLTS, 1000 v and for resistance measurements the meter is ready for use. For use on the millivolt and ammeter scales, allow a stabilization period.

2.3 Stabilization Period: Allow five minutes for drift stabilization, then with the selector switch turned to MA or MV, set the pointer to zero with the ZERO control.

The initial drift following turn-on results largely from the voltage drop of the RM-42R filament battery (BT-1) following application of load. During the first minute the voltage may drop several millivolts after which the rate of drop decreases rapidly and in five minutes the voltage becomes relatively stable. The longer time drift involves mainly the stabilization characteristics of the electro-

meter tube, which after an hour settles down appreciably and the meter drift becomes less than 1 mv per hour. The drift during the first hour with properly aged electrometer tubes should be in the order of 3 mv. If the instrument has not been operated for some time, the drift following turn-on will be greater than for day-to-day operation. Also, if the instrument is ON for long periods, the drift rate will decrease to much less than 1 mv per hour.

2.4 Voltage and Current Measurements: When making voltage measurements the COMMON test lead and shielded test lead with probe are used. When making current measurements, the COMMON and RESISTANCE-CURRENT leads are used. Observe the following precautions:

2.4.1 The Model 110A has high inherent overload capability. However, the procedure of starting with the less sensitive ranges and switching therefrom to the required scale should be observed. In general, over-voltages (and over-currents) in excess of 100 times the full scale value should not be applied. A maximum absolute voltage is 1500 peak, probe to meter COM, in the limit.

2.4.2 The measuring circuit is isolated from the case with an isolation resistance exceeding 10,000 megohms and a capacitance of approximately 250 micromicrofarads. The case may be grounded and the meter common operated up to 500 volts off ground.

2.4.3 If the 110A is used for current or voltage measurements in high potential circuits and it is not practical to turn off the equipment to make scale changes on the 110A, insulated extension shafts for the controls may easily be connected.

2.5 Resistance Measurements: When the selector switch is turned on the OHMS, KILOHMS or MEGOHMS position, resistance measurements may be made in these ranges with scale multipliers of 10 and 100 on the OHMS scale and 1, 10 and 100 on the KILOHMS and MEGOHMS scales.

Association of the multipliers with the OHMS, KILOHMS

and MEGOHMS scales has been indicated on the front panel by means of color dots. OHMS, with green dot, has its 10 and 100 multipliers also indicated with green dots, while the KILOHMS and MEGOHMS scales which both have 1, 10 and 100 multipliers carry the red dots. The 3, 30 and 300 multipliers are not used on any resistance scales, hence carry no color dots.

The 1 multiplier was omitted on the OHMS scale because the current requirements with 1 ohm center scale would exceed the capabilities of the "D" cell supplied. On the 10 ohm center scale, measurements should be made with reasonable rapidity because even on this scale current drain on the "D" cell is high.

The highest accuracy of resistance indication is at midscale so scales should be chosen to indicate in this vicinity. Except for readings below 3 ohms and above 300 megohms, measurements can be made between .3 and 3 on the resistance scale with greatest accuracy. CAUTION: Do not attempt to measure resistance in an energized circuit.

3. SOME APPLICATIONS

Enumerated below are a few special applications, (other than the usual functions an instrument measuring Voltage, Current and Resistance must perform) for which the Model 110A is useful.

3.1 High Resistance Measurement: (Above the range of the direct reading scales.) With an exterior high voltage source (e.g. 100-500 volts) the range of high resistance measurement of the Model 110A may be greatly extended. By connecting the unknown resistance between the voltage source and the RES-CUR terminal of the 110A, the current through it may be read. With the current and voltage known, the unknown resistance may be calculated. For example with a 500 v source and 1/10 of full scale on the 1 μ ma current scale, the unknown resistance would be 5×10^{12} ohms.

3.2 Offset Voltmeter: As an offset voltmeter, the Model 110A is connected between the unknown source of voltage and

a standard source of voltage. Because of the high input resistance of the 110A these voltage sources need not have low resistance outputs. The 110A will then read direct, deviations of the unknown from the standard voltage. The center zero meter scale is extremely useful in this application and battery power permits comparison at rather high voltages.

3.3 Probe Adaptation where input capacity must be a minimum. Although the input capacity of the voltage probe is in the order of 4 μf there are measurements where less than this is necessary for obtaining useful readings. If this is the case, the capacity loading may be further relieved by unscrewing the probe tip supplied and replacing it with a 1/2 watt resistor in the order of 1 megohm, one pigtail wrapped around the stud on the end of the probe, and the other pigtail cut to a length of approximately 1/4 inch to serve as the probe tip. If this resistor is 1 megohm it will affect the meter accuracy to the extent of 1.0% which may be taken into account or ignored as the required accuracy of the measurement may dictate.

3.4 Grid Current Measurement: The ammeter ranges of the Model 110A makes it suitable for the measurement of grid currents of vacuum tubes. In many measurements the voltage drop of an ammeter is not negligible. However, the Model 110A with its 100 millivolt full scale voltage drop is directly readable on the 1-0-1 scale for the voltage drop and the effect of ammeter insertion on the grid bias of the tube being tested may be read directly and appropriate compensation applied.

3.5 Semiconductor Characteristics: In the measurement of the static characteristics of semiconductors (diodes, transistors, etc.) the wide range of ammeter scales of the 110A are again useful. This range in many cases is adequate to cover both back and forward currents and polarity changes are readily handled with the center zero meter.

3.6 Deviation Bridge Indicator: When used as a deviation bridge limit indicator, full scale deflection on the

meter may be set to a percentage (1, 3, 10, etc.) off center by adjustment of the bridge voltage and the meter sensitivity. Component testing will then yield percentage of tolerance, or IN and OUT of tolerance limits as required.

3.7 The current ranges of the Model 110A may be extended, at some sacrifice of stability, down to ± 10 microamperes full scale by utilizing the VOLTS input and the MILLIVOLT ranges for current measurement. The ammeter shunt would be a constant 100 megohms.

4. CIRCUIT DESCRIPTION

The circuit of the Model 110A E-I-R Meter consists of three primary parts: (a) An input attenuator and resistance standards section; (b) a high gain feedback amplifier which acts as a high input resistance dynamic unit for repeating, at low impedance, the voltage at its input to (c) a metering circuit consisting of precision meter multipliers and an indicating meter.

4.1 Input Attenuator and Resistance Standards

4.1.1 The input attenuator for voltage measurements which comprises also the resistance standards for the ammeter shunts and comparison standards for resistance measurements, is composed of a string of precision resistors having a combined resistance of 100 megohms, $\pm 1\%$. A 1 megohm isolation resistor in the probe increases the input resistance for voltage measurements to 101 megohms.

(a) Voltage Measurements: For the ± 1 mv thru ± 1 volt ranges of the meter, the full scale input voltage to the high gain amplifier is $\pm 99\%$ of the range scale in use. For the remainder of the voltage scales this voltage is ± 990 mv.

(b) Current Measurements: The voltage drop across the ammeter shunts, which is applied to the high gain amplifier is ± 100 , $\pm 1\%$, mv for full scale deflection. Ammeter shunt values are selected as a proper portion of the precision resistor string.

(c) Resistance Measurement: A "D" cell, having a maximum voltage of about 1.6 volts is used for a voltage supply to the series combination of an unknown resistor and the internal standard. Input to the amplifier will, in such measurements, vary from 0 to ± 1.6 volts.

The tolerance of the precision resistors is $\pm 1.0\%$. However, these resistors have been selected so that the attenuator ratios are within $\pm 0.5\%$. In addition, provision has been made to compensate for the aging effects of the deposited carbon resistors used. Aging of deposited carbon resistors is more pronounced in the high megohm values and with those used in the Model 110A (none higher than 25 megohm) this aging may be as high as 0.5% per year. Since aging is such that the resistance increases with time, the high value resistors have been selected low (2%) and have been trimmed to the proper value with composition resistors. The value of these composition resistors may be altered in recalibration of the instrument, if necessary.

4.1.2 Switching of this resistor network to accomplish the necessary measurements is shown in detail in Fig. 4. This switching is generally straight-forward; however, certain features should be indicated:

(a) When voltage is being measured the RES-CUR terminal is connected to COM.

(b) When resistance or current is being measured the VOLTS terminal is open.

(c) In the resistance measuring position, only 1, 10 and 100 multipliers are used. The input to the high gain amplifier in the 3, 30 and 300 positions is grounded and the meter needle goes to the left end of the scale. In the resistance positions, especially for OHMS $\times 10$, the 1 ohm resistor on the bottom of the resistance chain is shunted with another 1 ohm resistor, thereby reducing the resistance by $1/2$ ohms. This is done to correct for "D" cell internal resistance and meter internal wiring resistance.

(d) For the 100 and 300 ma current scales, contacts are paralleled for lower contact voltage drop on switch SW-2.

(e) For the milliamperere current ranges the amplifier input is switched (by SW-3A) so that it measures the voltage across the ammeter shunt resistance and a maximum of one set of contacts, thereby minimizing the effects of contact resistance on current measuring accuracy.

4.2 Measuring Amplifier: The Model 110A employs a three tube, three transistor direct-coupled feedback amplifier with a CK-5886 electrometer tube in its input circuit. A circuit diagram of the instrument with the ON-OFF switch in the ON position is shown in Fig. 2. Battery check provisions are not shown.

4.2.1 Grid Input Filter: The input grid (CK-5886 electrometer tube) has a series 22 megohm resistor and shunt .0033 mfd capacitor to limit the grid current on overload and decrease the effect of superimposed AC. With 60 cycle superimposed AC, the ratio of superimposed AC (rms volts) to DC volts full scale meter reading for a 1% of full scale shift in indication on the 1 volt scale is approximately 15. This ratio is for the least favorable condition with -1 volt DC indicating. For the lower full scale ranges the ratio is higher (greater than 30) and is only slightly lower on the ranges above 30 volts. Superimposed AC (sine wave) first affects the meter reading when the voltage swing on the input grid reaches a magnitude where the output transistor reaches cut-off on negative voltage excursions.

The response time of the instrument is approximately 1/2 second. The grid circuit time constant was chosen to avoid increasing this figure unduly. On the 1 mv through 1 volt scales, the time for the pointer to return to zero on removal of the test probe from a circuit under test will be approximately two seconds.

4.2.2 Electrometer Input Tube: The CK-5886 input tube is

operated at a bias of approximately 1.9 v determined by one "N" cell (BT-5) and the drop across the 27 ohm filament resistor in series. Zeroing of the instrument is executed through control of the screen grid potential on this tube and is by means of a ten turn potentiometer providing fine adjustment and a screw-driver adjustable control for infrequent coarse adjustment. Overall feedback is achieved by common cathode-emitter coupling from the output transistor to the CK-5886 thru BT-5.

4.2.3 Amplifier: The electrometer input tube is followed by a multi-stage amplifier employing both vacuum tubes and transistors. V-2, a CK-6419 subminiature tube, provides voltage gain and minimum loading on the electrometer tube plate circuit. V-3, an additional CK-6419, operating as a cathode follower, couples the tube section to the base of the first transistor. The tube circuit is conventional with C-3 and R-9 serving to shape the gain characteristic for feedback stabilization. Use of a cathode follower to drive the base of the first transistor provides a source of current capable of meeting the varying base current needs of the transistor dictated by temperature changes. It also provides a source of optimum impedance for minimizing the effects of drift resulting from these temperature changes.

The transistor section of the complete amplifier utilizes three transistors in a direct-coupled n-p-n, p-n-p, n-p-n combination with minimum interstage coupling loss. Transistors TR-1 and TR-2 operate with nominal collector currents of 100 microamperes each while the output transistor TR-3 has a quiescent collector current of slightly under 1 ma. This transistor serves to supply the energy required for driving the indicating meter. Since the meter always reads "up-scale" when resistance measurements are being made the quiescent current of TR-3 is decreased for the resistance positions of SW-2 by adding R-15 (1500 ohms) in series with R-14 (5600 ohms). This additional resistance decreases the TR-3 quiescent current to approximately 750 microamperes. R-¹¹~~12~~ and C-4 provide additional gain characteristic shaping for feedback stabilization.

The current gain of the transistor section of the amplifier, base of TR-1 to collector of TR-3, is typically 8000. The voltage gain, base-emitter voltage of TR-1 to emitter-COMMON voltage of TR-3, is important in determining overall amplifier loop gain. This gain varies from a typical unity for the 1 millivolt range to 500 for the 1 volt range. With the typical 500 gain of the vacuum tube section (to the base of TR-1) the overall amplifier loop gain has a minimum value in the order of 500 on the 1 millivolt range.

4.2.4 Metering Circuit: From Fig. 2 it may be seen that the loop feedback voltage is developed across a meter sensitivity resistor (chosen from R-20 through R-30). With high loop gain this voltage will reproduce the voltage at the input grid of V-1 to a high degree of accuracy and a proper choice of resistor value will force a required current thru the resistor at the desired input voltage. Note that the loop feedback voltage is determined primarily by the current thru a precision wire wound resistor and not the current thru the meter resistance: temperature effects on the resistance of the meter moving element copper coil are hence negligible.

The current to the metering circuit for full scale deflection on the meter is ± 120 microamperes. The indicating meter requires ± 100 , $\pm 1/2\%$, microamperes. The additional current flows through R-16 which provides a trim on the meter sensitivity but mainly shunts the meter for desired dynamical performance.

As mentioned in Sec. 4.1 the input voltage to the high gain amplifier for full scale deflection on the indicating meter is 1 mv up to 1.6 volts depending on the measurement being made. The meter sensitivity resistors are switched to provide these full scale readings. Left zero operation of the meter (when resistance measurements are being made) is obtained through a meter biasing circuit employing an RM-1R mercury cell (BT-15) and an adjustable

series resistor. Because of the voltage stability of the RM-1R battery, adjustment of this resistor is of a secondary nature and therefore is not a front panel control.

An AMPLIFIER OUTPUT is provided in the form of connections across an 8333, $\pm 0.5\%$, ohm resistor in series with the indicating meter. 120 Microamperes thru this resistor gives an output of 1 volt for full scale deflection on the meter. A high impedance load across these output terminals (high-impedance recorder, relay circuit, etc.) will effect the output voltage only in proportion to its shunting effect on the 8333 ohm resistor. Should a current requiring load (low resistance coil, e.g.) be connected the circuit will supply up to ± 120 microamperes. Negligible effect on indicating meter accuracy results from open circuit of, to shorting the output terminals. The black terminal of AMPLIFIER OUTPUT is connected to the meter COMMON terminal. A polarity reversal occurs from the Model 110 input to AMPLIFIER OUTPUT.

The metering circuit serves the additional function of providing battery check capability. The voltages of batteries BT-1 and BT-7, supplying filament current to the CK-5886 and to the two CK-6419s in series, are checked under operating load. The meter multiplier for checking BT-1 (BATT-TEST A₁ position) is R-58 and the meter multiplier for checking BT-7 (BATT-TEST A₂ position) is R-59. The lower limit of the USEFUL BATT RANGE indication is 1.1 volt, a voltage only slightly greater than that at which the rapid fall-off of the mercury cell occurs. Also checked by direct metering (BATT-TEST B position) are the two 5 volt "B" batteries BT-13 and BT-14 in series. The meter multiplier for checking these batteries is R-60. Battery test circuitry is shown in detail in Fig. 3.

5. MAINTENANCE AND ADJUSTMENT

5.1 Precautions. Observe the procedure for opening the instrument for Inspection and Maintenance presented on page 2 of this manual.

The microammeter providing output indication for the Model 110A E-I-R Meter is a precision electro-mechanical device. Avoid unnecessary abuse of this device by careful handling of the instrument. Mechanical shock, in particular, may damage the meter jeweled bearings and impair meter performance.

The input circuit of the 110A involves components of extremely high resistance. Do not leave the instrument open for long periods of time lest dust settle on these components; dust which later may provide leakage paths when combined with moisture. Avoid handling of the CK-5886 electrometer tube near the grid seal. If this is inadvertently done, clean the glass envelope with cleansing tissue dampened with alcohol. The CK-5886 electrometer tube may be slightly photoelectric---do not make adjustments with the instrument out of the case with much light shining on the CK-5886. If it becomes necessary to replace components mounted on the printed wiring board, do so carefully and with a minimum of heat from a soldering iron.

5.2 Batteries. Batteries supply the operative power for the Model 110A. Approximately 1000 hours of operation are available before any replacement is necessary. At the end of this time batteries BT-1, BT-7 (RM-42R's) and BT-13 and BT-14 (TR-134R's) require replacement. This necessity will be indicated by the battery test provisions discussed previously. (Sec. 4.2.4)

Battery BT-16 ("D" cell) life will depend on the extent to which the instrument is used for the measurement of small value resistors where the battery drain may reach 150 ma (on the 10 ohm center range). This battery may fail first through increase in its internal resistance to the point where the accuracy limits of the meter will be exceeded on the 10 ohm center scale. To check the condition of this battery, measure a known 10 ohm resistor: A reading less than 9.5 ohm indicates a failing "D" cell.

The remainder of the batteries will have a service

life approximately equal to their shelf life (in the order of two years). Should BT-1, BT-7, BT-13 and BT-14 check satisfactory, inability to zero the instrument within the range of the ZERO control is most probably an indication of failure of one of the remaining batteries. The most probably sequence of failure would be BT-9¹¹, BT-10¹² and then BT-5, BT-8, et cetera.

CAUTION: Storage of the instrument in an environment having a temperature in excess of 40°C for protracted periods of time can result in a loss of expected service life of the batteries used.

5.3 Adjustment.

5.3.1 Center Zero Rheostat Adjustment. As mentioned in Sec. 4.2.4 a meter biasing circuit is employed to left zero the meter for resistance measurements. Adjust this biasing circuit as follows:

(a) Check mechanical zero on the meter with the instrument turned off. Adjust, if necessary.

(b) Turn instrument on and allow to stabilize. Then switch the E-I-R SELECTOR SWITCH to the MA position and adjust the ZERO control (front panel) to zero. Switch the E-I-R selector to OHMS and the RANGE SELECTOR to 3, 30 or 300. Adjust the ZERO ADJ rheostat on the printed wiring board to zero on the RESISTANCE scale.

5.3.2 Calibration. Calibration of the instrument should be checked periodically. In normal service, little other than aging of the high megohm resistors should affect this calibration. Trim resistors (see Sec. 4.1.1 of this manual) afford ease of compensation for this aging. When replacing resistors, observe reasonable precautions to avoid mechanical damage to the resistors on the range switch and to prevent damage from excessive unnecessary heat from soldering irons.

The Model 110A E-I-R Meter may be returned to THE

~~BELLEVILLE~~-HEXEM Corporation for repair and recalibration. Please notify us of your intention to do so, so that we may be prepared to give you prompt service.

WARRANTY

This instrument is guaranteed to the original user to be free from defects in material and workmanship for a period of one year from date of purchase. Our responsibility under this warranty is limited to the repair or replacement of the instrument, or any part thereof, failure of which is not due to abuse and excepts batteries that have given normal service.

For service under this warranty, promptly advise the factory of all details pertinent to the failure. Replacement parts will be shipped, via air transportation upon request, prepaid to any point within the continental United States or Canada. Should it be more convenient to ship the entire instrument, transportation prepaid, to the factory, it will be serviced as required, at no charge and returned via surface transportation.

Replacement parts ordered after termination of warranty will be billed at current net prices and shipped via air prepaid to any point within the continental United States or Canada.

PARTS LIST

<u>Circuit</u> <u>Symbol</u>			<u>Batteries</u>	<u>B-H Part</u> <u>Number</u>
BT-1	RM-42R	1.34 v	Mercury	101 010
BT-2	2U6 or 216	9 v	Carbon-Zinc	101 042
BT-3	"N" cell	1.5 v	Carbon-Zinc	101 021
BT-4	"N" cell	1.5 v	Carbon-Zinc	101 021
BT-5	"N" cell	1.5 v	Carbon-Zinc	101 021
BT-6	2U6 or 216	9 v	Carbon-Zinc	101 042
BT-7	RM-42R	1.34 v	Mercury	101 010
BT-8	"N" cell	1.5 v	Carbon-Zinc	101 021
BT-9	2U6 or 216	9 v	Carbon-Zinc	101 042
BT-10	U10 or 411	15 v	Carbon-Zinc	101 040
BT-11	"N" cell	1.5 v	Carbon-Zinc	101 021
BT-12	"N" cell	1.5 v	Carbon-Zinc	101 021
BT-13	TR-134R	5 v	Mercury	101 104
BT-14	TR-134R	5 v	Mercury	101 104
BT-15	RM-1R	1.34 v	Mercury	101 001
BT-16	"D" cell	1.5 v	Carbon-Zinc	101 020

Battery type designations are Mallory, Eveready, or Burgess.

Capacitors

C-1	100 mmfd	500 v	Tubular Ceramic	10%	104 032
C-2	3300 mmfd	600 v	Disc Ceramic	20%	103 169
C-3	.02 mfd	300 v	Disc Ceramic	20%	103 181
C-4	.1 mfd	100 v	Disc Ceramic	20%	103 205
C-4.5.8	.001 mfd	"	"	"	103 156
C-6	150 mmfd	"	"	"	

Meters

M-1	100-0-100 Microamperes	270 002
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Resistors

R-1	22 meg	1/2 w	Comp.	10%	301 226
R-2	27 ohm	1/2 w	WW	10%	320 125
R-3	10 k	2 w	WW pot	10%	273 005
R-4	5 k	4 w	WW 10 turn pot	5%	279 002
R-5	10 k	1/2 w	Dep. Carbon	1%	311 103
R-6	300 k	1/2 w	Dep. Carbon	1%	311 304
R-7	12 meg	1/2 w	Comp.	10%	301 126
R-8	4.7 meg	1/2 w	Comp.	10%	301 475
R-9	47 ~~39~~ k	1/2 w	Comp.	10%	301 ~~393~~ 473
R-10	180 k	1/2 w	Comp.	10%	301 184

Circuit Symbol		Resistors, Cont'd.			B-H Part Number
R-11	1500 ohm	1/2 w	Comp.	10%	301 151
R-12	27 k	1/2 w	Comp.	10%	301 273
R-13	100 k	1/2 w	Comp.	10%	301 104
R-14	5.6 k	1/2 w	Comp.	10%	301 562
R-15	1.5 k	1/2 w	Comp.	10%	301 152
R-16	Selected	1/2 w	Dep. Carbon	1% Meter Sens. Trim	
R-17	2 k	1 w	WW Rheostat	10% RES. ZERO ADJ.	273 003
R-18	9 k	1/4 w	Prec. WW	.1%	317 019
R-19	8333 ohm	1/4 w	Prec. WW	.5%	317 018
R-20	8.2 ohm	1/4 w	Prec. WW	.1%	317 010
R-21	24.7 ohm	1/4 w	Prec. WW	.1%	317 011
R-22	82.5 ohm	1/4 w	Prec. WW	.1%	317 012
R-23	247.5 ohm	1/4 w	Prec. WW	.1%	317 013
R-24	825 ohm	1/4 w	Prec. WW	.1%	317 014
R-25	2475 ohm	1/4 w	Prec. WW	.1%	317 016
R-26	8250 ohm	1/4 w	Prec. WW	.1%	317 017
R-27	850 ohm	1/4 w	Prec. WW	1%	317 015
R-28	Selected	1/2 w	Comp.	10%	
R-29	3.9 k	1/2 w	Dep. Carbon	1%	311 392
R-30	2 k	2 w	WW pot.	2% RES. ADJ.	273 004
R-31	20 meg	2 w	Dep. Carbon	1%	313 206
R-32	22.8 meg	2 w	Dep. Carbon	1%	314 012
R-33	22.8 meg	2 w	Dep. Carbon	1%	314 012
R-34	Trim Res.	1/2 w	Comp.		
R-35	22.8 meg	2 w	Dep. Carbon	1%	314 012
R-36	Trim Res.	1/2 w	Comp.		
R-37	6.53 meg	1 w	Dep. Carbon	1%	314 011
R-38	Trim Res.	1/2 w	Comp.		
R-39	2.28 meg	1/2 w	Dep. Carbon	1%	314 010
R-40	Trim Res.	1/2 w	Comp.		
R-41	653 k	1/2 w	Dep. Carbon	1%	314 009
R-42	Trim Res.	1/2 w	Comp.		
R-43	228 k	1/2 w	Dep. Carbon	1%	314 008
R-44	Trim Res.	1/2 w	Comp.		
R-45	66.67 k	1/2 w	Dep. Carbon	1%	314 007
R-46	23.33 k	1/2 w	Dep. Carbon	1%	314 006
R-47	6.667 k	1/2 w	Dep. Carbon	1%	314 005
R-48	2.333 k	1/2 w	Dep. Carbon	1%	314 004
R-49	666.7 ohm	1/2 w	Dep. Carbon	1%	314 003
R-50	233.3 ohm	1/2 w	Dep. Carbon	1%	314 002
R-51	66.67 ohm	1/2 w	Dep. Carbon	1%	314 001
R-52	23.3 ohm	2 w	Prec. WW	1%	317 005
R-53	6.67 ohm	2 w	Prec. WW	1%	317 004
R-54	2.33 ohm	2 w	Prec. WW	1%	317 003
R-55	.667 ohm	2 w	Prec. WW	1%	317 002

Circuit
Symbol

Resistors, Cont'd.

B-H Part
Number

R-56	.333 ohm	2 w	Prec. WW	1%	317 001
R-57	1.0 ohm	1/2 w	WW	10%	320 108
R-58	16.7 k	1/2 w	Dep. Carbon	1%	314 013
R-59	16.7 k	1/2 w	Dep. Carbon	1%	314 013
R-60	147 k	1/2 w	Dep. Carbon	1%	314 014
R-61	1 meg	1/2 w	Comp.	10%	301 105
R-62	470 k	"	"	"	301 474

Switches

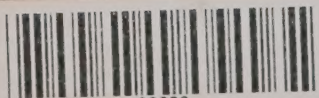
SW-1	3 wafer	5 position	rotary	ON-OFF BATT TEST	332 004
SW-2	6 wafer	6 position	rotary	RANGE SELECTOR	332 005
SW-3	5 wafer	9 position	rotary	E-I-R SELECTOR	332 006

Transistors

TR-1	¹³⁰² ~~2N364~~ or equal	Amplifier		325 001
TR-2	2N207 or equal	Amplifier		325 002
TR-3	¹³⁰² ~~2N364~~ or equal	Output		325 001

Vacuum Tubes

V-1	CK-5886	Electrometer Input	Selected and Aged	335 001
V-2	CK-6419	Voltage Amplifier		335 003
V-3	CK-6419	Cathode Follower		335 003



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